Libby Dam: Kootenai River and Lake Koocanusa Water Quality Sampling and Analysis Plan 2019

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Introduction

During the 2019 calendar year, the Seattle District Corps of Engineers will continue a water quality study started in 2005 of Lake Koocanusa and the Kootenai River, the waterbodies regulated by operations at Libby Dam. Continued water quality monitoring is needed to maintain adequate information on the physical, chemical, and biological condition of Lake Koocanusa and the Kootenai River from which any future changes can be assessed. This data will allow the Seattle District to define the relationship between Libby Dam and the water quality in Lake Koocanusa and the Kootenai River. An understanding of the possible impact of Libby Dam on the water quality in Lake Koocanusa and the Kootenai River is of paramount importance because of the current, proposed, and possible future Lake Koocanusa and Kootenai River Total Daily Maximum Loads (TMDLs) for various water quality parameters that may be implemented by the Montana Department of Environmental Quality (MDEQ), Idaho Department of Environmental Quality (IDEQ), and the United States Environmental Protection Agency (EPA). Furthermore, historic and current coal mining in the Lake Koocanusa watershed in British Columbia has substantially degraded water quality in the Elk River, a major tributary to Lake Koocanusa. Hauer and Sexton (2013) reported increased loadings of selenium, nitrogen, and sulfate from coal mining activities in British Columbia to Lake Koocanusa and the Kootenai River suggesting that the sediment quality and water quality entering the lake has been degraded.

Continued water quality monitoring will allow the Seattle District to share data and work together with the United States Geological Survey (USGS), MDEQ, and the EPA to develop (1) meaningful Lake Koocanusa and Kootenai River TMDLs, and (2) a site specific Se standard for Lake Koocanusa. In addition, baseline water quality data will help the Seattle District define the relationship between Libby Dam and the water quality and beneficial uses in the lake and river, including fisheries, recreation, and water supply.

This sampling and analysis plan provides details on the methods and protocols that will be used for water quality sampling at Libby Dam. This sampling and analysis plan was developed in accordance with *Guidelines for Quality Assurance Project Plans* (U.S. EPA 1998) and includes the following elements:

- Project organization and schedule
- Project description
- Sampling procedures
- Analytical procedures
- Data quality objectives
- Data assessment procedures and corrective actions
- Data management procedures and reporting.

Project Organization and Schedule

The following section will outline the project organization and schedule for the Kootenai River and Lake Koocanusa water quality monitoring project.

Project Organization

The Seattle District is the project proponent and lead agency for the Libby Dam water quality monitoring program. The Seattle District and Libby Dam personnel are responsible for conducting all water quality monitoring in the Kootenai River and Lake Koocanusa. Washington State Department of Ecology (Ecology) or U.S. EPA approved laboratories will be responsible for chemical analysis of the water samples. Specific responsibilities of key personnel are shown below:

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Project Schedule

The water quality monitoring program shall collect periodic surface water samples in the Kootenai River and Lake Koocanusa during 2019. Water quality samples will be delivered to the laboratory within 48 hours of collection. The water quality laboratories will report the analytical results to the Seattle District principal investigator within 30 days. The sample and quality control data will be reviewed by the quality assurance (QA) officer within 90 days of the final set of data from the laboratory. A draft project report will be completed within 6 months of the QA review of the final set of data from the laboratory. A final project report will be completed within 3 months of receiving comments on the draft project report.

Project Description

The following section will provide background information, previous water quality investigations, project goals and objectives for the Kootenai River and Lake Koocanusa water quality monitoring project.

Background Information

Libby Dam is located 18 miles northeast of Libby, Montana at river mile (RM) 221.9 of the Kootenai River (Figure 1). The dam's reservoir, Lake Koocanusa, is 90 miles long, extending 42 miles into British Columbia, Canada. The dam is a concrete gravity structure rising about 430 feet above bedrock with a top length of about 3075 feet. The reservoir has a gross storage capacity of 5.81 million acre feet (MAF), a mean depth of 126 feet, a maximum depth of 350 feet at the forebay, and a mean water residence time of about 9 months. Normal full pool and minimum regulated reservoir elevations are 2,459 and 2,287 feet, respectively. Downstream of Libby Dam, the Kootenai River flows to the south for about 3 miles to the mouth of the Fisher River and then to the northwest for about 71 miles to Bonners Ferry, Idaho through a relatively steep canyon with an average slope of about 5 feet per mile. At Bonners Ferry, the river valley widens and the river meanders to the north through a relatively flat section for about 47 miles to the Canadian Border (Figure 1).

The Lake Koocanusa watershed is dominated by high, forested, northwest trending mountain ranges separated by narrow river valleys. Elevations range from about 2,100 feet immediately downstream of Libby Dam to over 11,000 feet in the Rocky Mountains of British Columbia. The topography near Libby Dam is characterized by steep mountain slopes that plunge directly into the lake as well as relatively flat terraces that lie at intervals between the lake and the mountain slopes. The mountains rise as much as 2,000 feet per mile from the lake and vegetation is dominated by ponderosa pine, Douglas-fir, western larch, western red cedar, western hemlock, and lodgepole pine (USDA 1995). The lake width ranges from about 0.5 miles at Libby Dam to about 2.5 miles near the Canadian Border.

The climate of the study area is influenced by easterly moving weather systems from the Pacific Ocean. Winters are generally cloudy, cool, and wet, with November through March being the wettest months. Most of the snowpack in the mountains falls between November and April. Summers are typically warm and dry, with little rainfall occurring from June through September. The mean annual precipitation at Libby is about 19.4 inches (USDA 1995). Total annual snowfall varies with elevation, with about 60 inches near the dam to an estimated 300 inches in some mountain areas. The average monthly temperatures at Libby range from -5.6°C in January to 18.8°C in July, with extremes recorded in the vicinity of the dam of – 43.3 °C and 43.7°C (USCOE 1984).

Much of the annual runoff in the Kootenai River valley occurs in spring with the snowmelt. The impoundment of the Kootenai River by Libby Dam in 1972 for flood control and hydroelectric
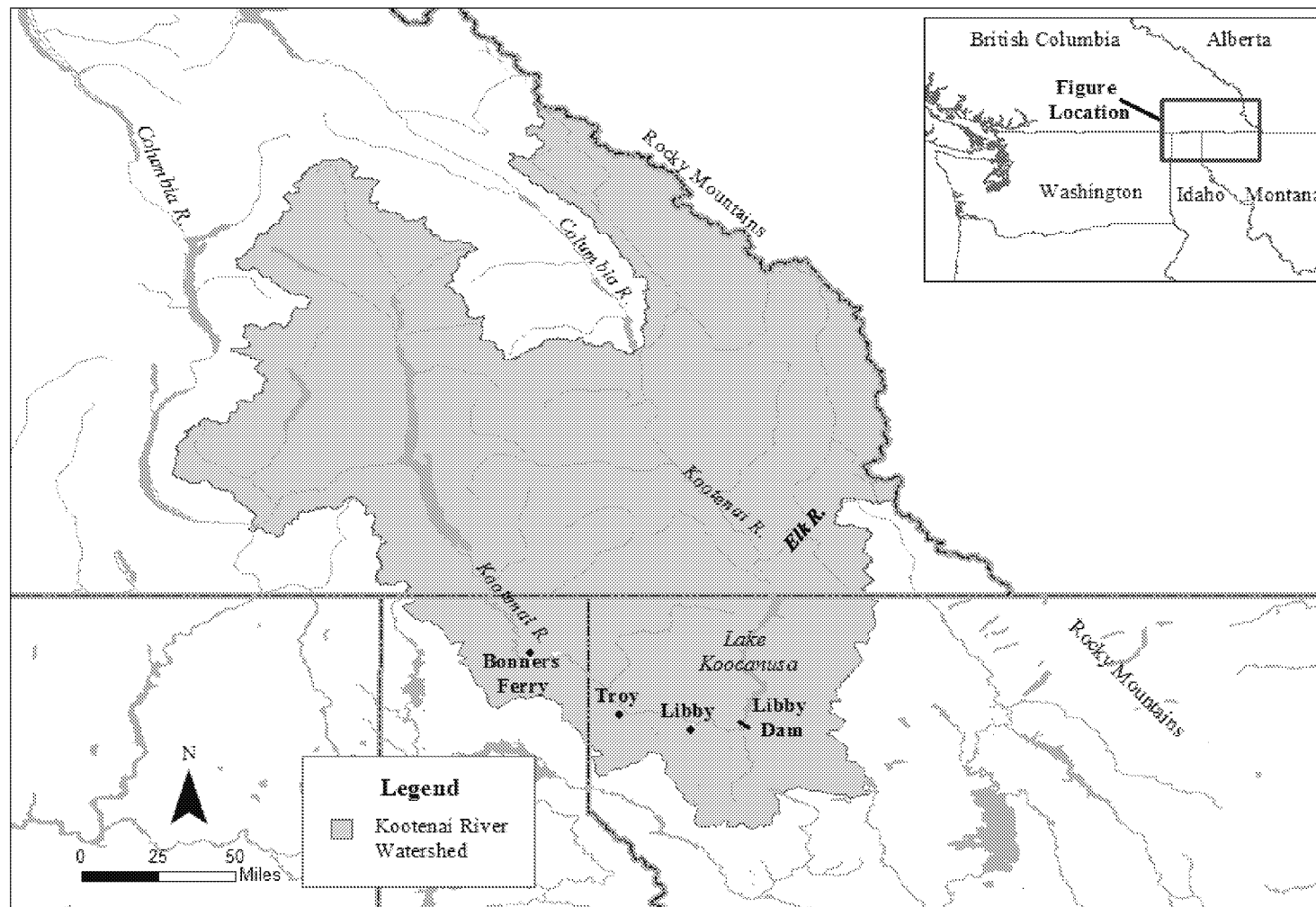
Figure 1.   Location of Libby Dam and the Kootenai River watershed.

power production altered the seasonal flow patterns of the river (Bonde and Bush 1982). The annual pre-impoundment runoff conditions for the Kootenai River at the town of Libby showed high flows from April through June time period, with relatively low runoff the rest of the year, especially in the dry late summer/fall period, and the cold winter periods (Bonde and Bush 1982). Average pre-impoundment (1912 – 1971) flows in the Kootenai River ranged from about 65,000 cubic feet per second (cfs) in late May and early June to about 4,000 cfs in January (USGS 2003). Post-impoundment conditions (1972 – 2001) have resulted in retaining water during historical high flow periods and discharging water during historical low flow periods. Since the early 1990s the COE has increased spring discharge levels to benefit downstream sturgeon survival. In general, the Kootenai River experiences reduced flows for most of the year, with peak flows of up to 26,000 cfs in late May through June for sturgeon survival.

Previous Investigations

Water quality sampling of Lake Koocanusa and the Kootenai River was conducted by the USGS for the Seattle District from 1967 through 2004. The water quality program consisted of collecting monthly samples at three in-reservoir stations from May to October and at one downstream station from February to December. In-reservoir stations were located about 48 miles upstream of Libby Dam near the international border, 10 miles upstream of the dam near Ten Mile Creek, and at the forebay, while the downstream station was located about 0.6 miles downstream at the site of the USGS gaging station (No. 12301933) (see Figure 1). Additional sampling stations were added and removed over time for special studies, however the four core stations noted above remained the same during this time period.

The in-reservoir water quality program conducted by the USGS consisted of conducting vertical profiles of water quality at each station (temperature, conductivity, dissolved oxygen, and pH) and collecting monthly grab samples in the reservoir from May to October from about 3 meters above the reservoir bottom and 3 meters below the reservoir surface. These grab samples were analyzed for nutrients (monthly), major ions (twice per year), and trace metals (twice per year). Additionally, a photic zone composite sample was collected and analyzed for Chlorophyl a (monthly). The river water quality program consisted of collecting monthly depth integrated samples from February to December at the USGS tailwater gaging station. These depth integrated samples were analyzed for nutrients (monthly), major ions (twice per year), and trace metals (twice per year).

Although limnological data was collected on Lake Koocanusa from 1967-2004 and considerable data analysis of pre-dam (1967-1971) versus post-dam (1972-1980) has been performed (Woods 1980; Bonde and Bush 1982; Storm et al. 1982; Whitfield and Woods 1984) little water quality analysis has been conducted on the post-1980 data. Bonde and Bush (1982) predicted that pre-impoundment loadings of nitrogen and phosphorus in the Kootenai River would lead to post-impoundment eutrophic conditions in Lake Koocanusa. However, beginning in 1976, phosphorus concentrations were substantially reduced because of improved wastewater treatment at a fertilizer plant upstream of the reservoir. Woods (1982) concluded that even though the trophic state of Lake Koocanusa would be classified as eutrophic based on nutrient loadings, the water quality and primary productivity data classify the reservoir as oligotrophic. This

discrepancy in predicted versus actual trophic state was a result of limnological processes in the reservoir which cause nutrients entering the reservoir to be largely unavailable to phytoplankton because these nutrients are carried beneath the euphotic zone and they are settled out and removed from the water column due to the long residence time in the reservoir (Woods 1982). Little water quality analysis on data collected since 1980 has been completed on Lake Koocanusa.

Coal Mining Impacts

The Elk River originates in southeastern British Columbia and is a major tributary to the Kootenai River and Lake Koocanusa (see Figure 1). Historic and current coal mining in the watershed has degraded the sediment and water quality in the Elk River entering Lake Koocanusa. Hauer and Sexton (2013) reported elevated loadings of selenium, nitrogen, and sulfate from the Elk River in British Columbia to Lake Koocanusa and the Kootenai River. The USGS (2014) determined that selenium loading to Lake Koocanusa from the Elk River increased 5-fold between 1992 and 2012. The increased loads of these elements from the Elk River pose a serious ecological threat to fish and aquatic birds in Lake Koocanusa. In particular, increased selenium loading is of concern because selenium can bioaccumulate in the food web and is toxic to fish and aquatic birds.

Project Goals and Objectives

The goal of the proposed sampling program is to continue to collect baseline data for the Kootenai River downstream of Libby Dam and for Lake Koocanusa. This data will allow the Seattle District to properly address and respond to any future water quality criteria issues on Lake Koocanusa and the Kootenai River. Although the most pressing water quality issues are currently total dissolved gas (TDG) and temperature in the Kootenai River downstream of Libby Dam, it is possible that future water quality concerns in the Kootenai River will include nutrients, metals, and biological parameters. Baseline water quality data will allow the Seattle District to understand the relationship between Libby Dam and the water quality and beneficial uses in the Kootenai River and Lake Koocanusa.

The objective of the monitoring program is to determine the existing physical, chemical, and biological condition of Lake Koocanusa and the Kootenai River at Libby Dam. Meeting this objective will allow the Seattle District to compare existing water quality to Montana State standards, determine any project related water quality impacts, and understand the role of Libby Dam on the water quality in Lake Koocanusa and the Kootenai River.

Sampling Procedures

Sampling procedures will generally follow Puget Sound Estuary Program (PSEP) protocols (U.S. EPA 1990, 1997) and United States Geological Survey (USGS) protocols (USGS 1999). Prior to each sampling event, the COE principal investigator will review sampling procedures and equipment needs with field technicians. This section identifies specific procedures for water sampling, preparing field notes, and decontaminating equipment. It also describes requirements for sample containers, preservation, holding times, identification, labeling, and handling.

Sampling Design

To meet the project goals and objectives described in the previous section, water quality will be monitored at Libby Dam at three (3) stations in Lake Koocanusa and one (1) station located downstream of the dam (Figure 2). Downstream station LIBTW will be located on the Kootenai River about 0.3 miles downstream of Libby Dam at the David Thompson Bridge and collected at mid-channel from the bridge. The in-reservoir stations will consist of one (1) up-reservoir station located about 48 miles upstream of Libby Dam near the Canadian-U.S. border (LIBBOR), one (1) mid-reservoir station located about 10 miles upstream of Libby Dam near Ten Mile Creek (LIBTMC), and one (1) forebay station located immediately upstream of the dam (LIBFB). The in-reservoir stations will be collected from the reservoir thalweg which represents the deepest point at each sampling location. Water quality parameters of concern include temperature, pH, dissolved oxygen, alkalinity, nutrients (i.e. phosphorus and nitrogen), major ions, metals, and plankton (Table 1).

Water Quality Sampling

From April through October 2019, water quality data will be collected for the Seattle District's water quality study at monthly intervals at one downstream river station (LIBTW) and three in-reservoir stations (LIBBOR, LIBTMC and LIBFB). Each sample will be analyzed for the parameters presented in Table 1, with the following exceptions. The metals aluminum, arsenic, chromium, copper and zinc will be collected only in May, July, and September, and biological samples will not be collected at station LIBTW. During the study, three sets of field duplicates and field blanks (May, July and September sampling dates) will be collected to assess both environmental and analytical variability.

All water quality sampling will be performed by two field technicians wearing new powder-free vinyl gloves. In-reservoir (LIBBOR, LIBTMC, and LIBFB) samples will be collected by submerging a cleaned and decontaminated 3.0 liter (L) polycarbonate (Lexan) van-dorn style sampler with ultra-clean seals to depth and filling. A water quality sampler will be dedicated to
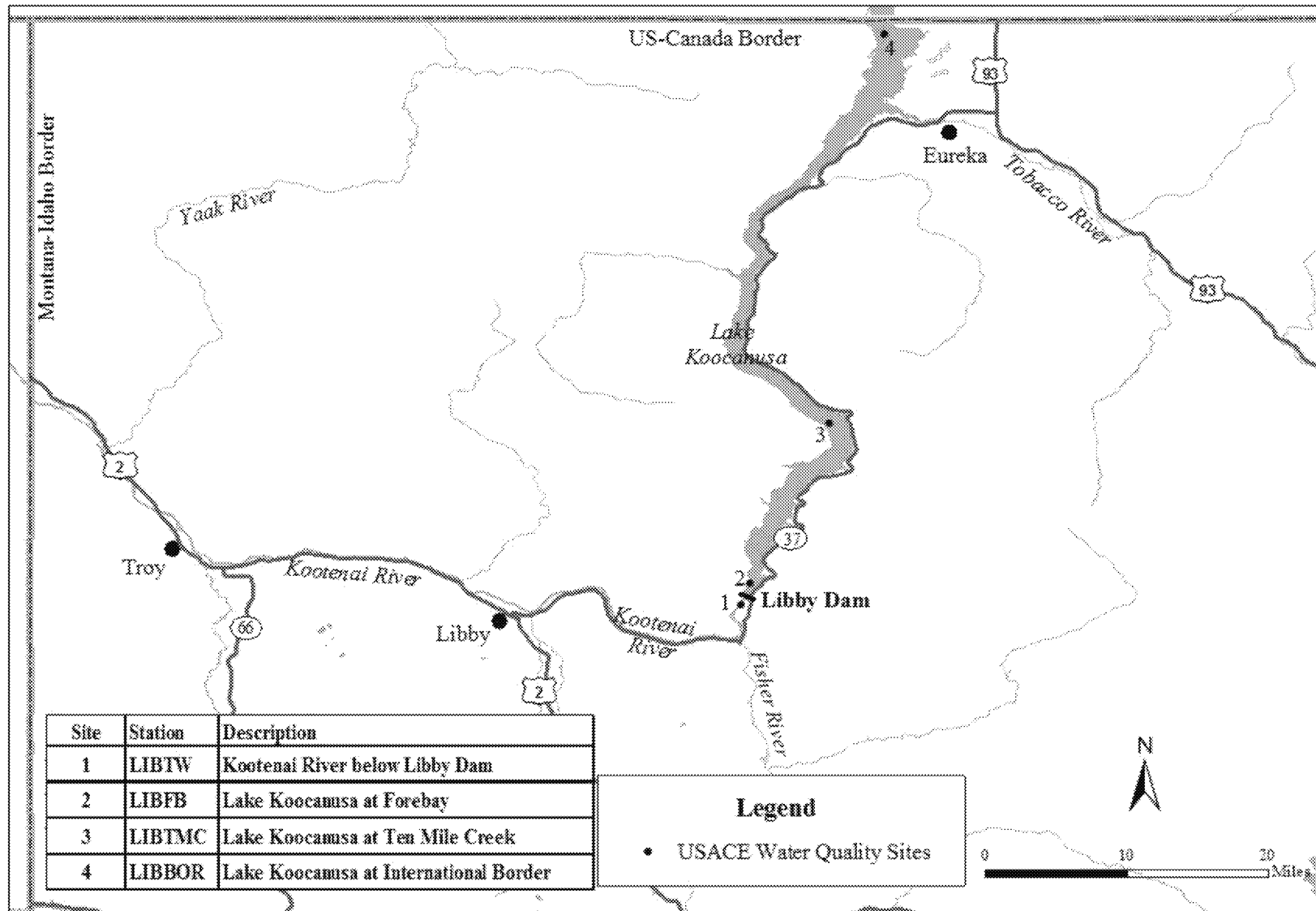
Site	Station	Description
1	LIBTW	Kootenai River below Libby Dam
2	LIBFB	Lake Koocanusa at Forebay
3	LIBTMC	Lake Koocanusa at Ten Mile Creek
4	LIBBOR	Lake Koocanusa at International Border

Figure 2. **Locations of water quality monitoring stations near Libby Dam.**

Table 1.   Methods and detection limits for water quality analyses.

	Method Number [a]	Detection Limit/Unit	Container and Preservative	Holding Time	Water Quality Stations Key
Laboratory Chemical Parameters					
Total Phosphorus	SM18 4500PF	0.002 mg/L	P/G, 4° C, H_2SO_4 to pH<2	28 days	A
Soluble Phosphorus	SM18 4500PF	0.001 mg/L	P/G, 4° C, filter immediately	48 hours	A
Total Nitrogen	SM20 4500NC	0.050 mg/L	P/G, 4° C, H_2SO_4 to pH<2	28 days	A
Nitrate+Nitrite	SM18 4500NO3F	0.010 mg/L	P/G, 4° C, H_2SO_4 to pH<2	28 days	A
Ammonia	SM18 4500NH3H	0.005 mg/L	P/G, 4° C, H_2SO_4 to pH<2	28 days	A
Alkalinity	SM18 2320B	1.00 mg/L	P/G, 4° C	14 days	A
Hardness	SM18 2340B	0.700 mg/L	P/G, 4° C, HNO_3 to pH<2	6 months	A
Calcium	EPA 200.7	0.100 mg/L	P/G, 4° C, HNO_3 to pH<2	6 months	A
Magnesium	EPA 200.7	0.100 mg/L	P/G, 4° C, HNO_3 to pH<2	6 months	A
Potassium	EPA 200.7	0.500 mg/L	P/G, 4° C, HNO_3 to pH<2	6 months	A
Sodium	EPA 200.7	0.500 mg/L	P/G, 4° C, HNO_3 to pH<2	6 months	A
Sulfate	SM18 4500SO4E	1.00 mg/L	P/G, 4° C	28 days	A
Chloride	SM18 4500CLC	0.50 mg/L	P/G, 4° C	28 days	A
Aluminum	EPA 200.8	0.003 mg/L	P/G, 4° C [b]	6 months	B
Arsenic	EPA 200.8	0.003 mg/L	P/G, 4° C [b]	6 months	B
Cadmium	EPA 200.8	0.00003 mg/L	P/G, 4° C [b]	6 months	A
Chromium	EPA 200.8	0.0020 mg/L	P/G, 4° C [b]	6 months	B
Copper	EPA 200.8	0.0010 mg/L	P/G, 4° C [b]	6 months	B
Lead	EPA 200.8	0.0001 mg/L	P/G, 4° C [b]	6 months	A
Selenium	EPA 200.8	0.0005 mg/L	P/G, 4° C [b]	6 months	A
Zinc	EPA 200.8	0.005 mg/L	P/G, 4° C [b]	6 months	B
Laboratory Biological Parameters					
Phytoplankton	–	–	P/G, 4°C, 1% Lugols	12 months	C
Zooplankton	–	–	G, 4°C, 25% Ethyl Alcohol	12 months	C
Zooplankton Selenium	EPA 1638	0.06 mg/kg	P/G, 4° C	48 hours	D
Chlorophyll a	SM 1810200H	0.0001 mg/L	P, 4°C, filter, add $MgCO_3$	28 days	C
Large Volume Sampling					
Particulate Selenium	EPA 1638	0.06 mg/kg	P/G, 4° C	6 months	E

[a] SM method numbers are from APHA et al. (2000); EPA method numbers are from U.S. EPA (1983, 1984, and 1992).
[b] Samples for analysis of total trace metals should be preserved within 24 hours with HNO_3 to pH<2. Samples for dissolved trace metals should be preserved within 24 hours with HNO_3 to pH<2 after filtration
A   Stations LIBTW, LIBBOR, LIBTMC, LIBFB for all months
B   Stations LIBTW, LIBBOR, LIBTMC, LIBFB for May, July, and September samples
C   Stations LIBBOR, LIBTMC, LIBFB for all months
D   Stations LIBBOR, LIBTMC, LIBFB for May, July and September samples
E   Stations LIBBOR and LIBFB for May, July and September samples

each station to prevent any cross contamination between stations. Samples will be collected from a depth of 3 meters below the surface (representative of the epilimnion) and 3 meters above the bottom (representative of the hypolimnion). Sample containers will be rinsed three times prior to filling, capped with headspace for mixing or the addition of preservative, and immediately placed on ice in a cooler. Photic zone samples for chlorophyll a analysis will be collected from up to five depths in the photic zone, and compositing them into a clean 22 L bucket at the surface.

Downstream in-river station LIBTW samples will be collected from the center of the river by submerging a dedicated cleaned and decontaminated 3.0 liter polycarbonate van-dorn style sampler with ultra-clean seals to depth and filling. All sample containers will be rinsed three times prior to filling, capped with headspace for mixing or the addition of preservative, and immediately placed on ice in a cooler. Measurements of field parameters (temperature, conductivity, dissolved oxygen, pH, turbidity) will be collected as a profile at 1 meter intervals at all stations in situ using a Hydrolab MiniSonde 5 multiprobe coupled with a Surveyor 4 surface display and recording unit. Equipment used for field measurements will be calibrated according to manufactures specifications prior to each sampling event.

Phytoplankton samples will be collected from the photic zone following the procedures used for chlorophyll a sample collection. Zooplankton samples intended for species identification and density analysis will be collected by vertical tow from a depth of 10 meters to the surface using a 64 μm mesh net. Phytoplankton and zooplankton samples will be immediately placed on ice in a cooler and preserved with either a 1-percent Lugols solution (phytoplankton) or 25-percent Ethyl Alcohol solution (zooplankton) within 12 hours of sample collection.

Large volume water samples for particulate selenium will be collected in pre-cleaned 19 liter high density polyethylene (HDPE) carboys at stations LIBBOR and LIBFB. Sampling will be scheduled based on the hydrograph with an effort to collect samples on both the rising and falling limb. It is expected that sampling will occur 3 or 4 times during the season, likely in May, June, July and September. Samples will be collected by submerging a cleaned and decontaminated 3.0 liter (L) polycarbonate (Lexan) van-dorn style sampler with ultra-clean seals to depth and filling. A water quality sampler will be dedicated to each station to prevent any cross contamination between stations. Samples will be collected from a depth of 3 meters below the surface and 3 meters above the bottom. Sample containers will be rinsed three times, filled, and immediately placed on ice in a cooler. Because of particulate mass limitations, two containers will be filled at the 3 meter depth at both locations. The samples from each depth and location will be stored and processed separately and analyzed as discrete samples. A field duplicate and field blank will be collected during each sampling trip. Samples will be shipped overnight to Georgia State University (GSU) lab for particle extraction and freeze drying. After particle extraction at Georgia State, the dried particulate samples will be shipped to Brooks Analytical Labs for total selenium analysis.

Zooplankton samples intended for selenium analysis will be collected 3 times per year (May, July, and September) at stations LIBBOR, LIBTMC, and LIBFB. Samples will be collected by vertical tow from a depth of 10 meters using an 80 μm mesh net. The number of tows collected will vary and will be based on obtaining enough zooplankton for the laboratory to analyze

selenium. A target of 10 grams/sample (estimated to take about 20 vertical tows) will be required for the selenium analysis. Once at least 10 grams of zooplankton has been collected, the sample will be transferred to a laboratory-cleaned sample container and placed, unpreserved, on ice in a cooler. Brooks Analytical Labs will perform the zooplankton selenium analysis.

Equipment Decontamination

Sampling equipment used during the project will be decontaminated prior to collection of samples using the following procedure:

- Wash with phosphate-free detergent
- Rinse thoroughly with deionized water
- Rise with a 5% hydrochloric acid solution
- Rinse thoroughly with deionized water.

Large Volume Sampling Particulate Selenium Recovery Standard and Field Blank

A particulate selenium recovery standard/field blank will be made every time large volume samples are collected and delivered to Georgia State University lab. Recovery samples/field blanks will be prepared by adding 3.00 g of powdered Weisner Quartzite (provided by Georgia State University) to a decontaminated 19 liter HDPE carboy filled with certified blank water (deionized water). The carboy will be gently shaken, and the cap covered with parafilm to ensure there is not any leakage. This sample will be shipped together with the large volume samples to Georgia State University where it will be used to determine the recovery of suspended sediment during the continuous centrifugation.

A field blank will also be assessed to determine if there was any contamination during the centrifugation, handling, and shipping of the samples. Selenium results from the recovery standard will be compared to selenium results from the Weisner Quartzite alone (dry, not subjected to centrifugation) to determine the field blank.

Field Notes

At each water quality monitoring station, the following information will be recorded in a waterproof bound field notebook:

- Sampling date and name of sampler
- Time of sample collection, measurement, or observation
- Station location
- Weather and flow conditions
- Calibration results for field instruments
- Field measurements
- Number and type of samples collected
- Modifications of established sampling procedures.

Sample Containers, Preservation, and Holding Times

Pre-cleaned sample containers will be obtained from the analytical laboratory for the required analyses. Spare sample containers will be carried by the sampling team in case of breakage or possible contamination. Sample containers, preservation techniques, and holding times will follow PSEP (U.S. EPA 1990), U.S. EPA (40 Code of Federal Regulations [CFR] 136, July 1, 1992) and Ecology (2001) guidelines (see Table 1).

Sample Identification and Labeling

Each sample will be identified by its station number and the date of collection. Prior to filling, sample containers will be labeled with the following information using indelible ink:

- Station ID
- Date of collection (month/day/year)
- Time of collection (military format)
- Project ID
- Company/sampler initials.

Sample Handling

Pre-cleaned sample containers will be provided by the analytical laboratory and secured in a clean cooler prior to use. Samples will be stored on ice at about 4° C in a cooler and transported to the laboratory within 48 hours of collection. A chain-of-custody record will accompany the samples that clearly identifies the analytical parameters and methods.

Analytical Procedures

Analytical methods and detection limits and are presented in Tables 1 and 2. Field measurements of temperature, pH, conductivity, turbidity and dissolved oxygen will be conducted in situ using portable meters operated according to the manufacturer's directions and following standard measurement procedures (APHA, et al. 2000). Laboratory analytical procedures will follow U.S. EPA approved methods (APHA et al. 2000; U.S. EPA 1983, 1984). These methods provide detection limits that are below the state and federal regulatory criteria or guidelines, and will enable direct comparison of analytical results with these criteria.

The laboratories used for this project will be certified by Ecology and participate in audits and interlaboratory studies by Ecology and U.S. EPA. These performance and system audits have verified the adequacy of the laboratory standard operating procedures, which include preventative maintenance and data reduction procedures.

The laboratory will report the analytical results within 30 days of receipt of the samples. Sample and quality control data will be reported in a standard format. The reports will also include a case narrative summarizing any problems encountered in the analyses.

Data Quality Objectives

The overall quality assurance objective is to ensure that data of known and acceptable quality are obtained. All measurements will be performed to yield consistent results that are representative of the media and conditions measured. Specific objectives and procedures for precision, accuracy, representativeness, completeness, and comparability are identified below. In this document, the term "detection limit" refers to the practical quantitation level established by the laboratory, not the method detection limit.

- **Precision.** Precision will be assessed using a laboratory duplicate that will be analyzed at random with every sample batch (i.e., sampling event) and a field duplicate that will be analyzed at a frequency of at least 5 percent of the total number of samples submitted (i.e., one in 20 samples). For inorganic analysis and total organic carbon, the relative percent difference (RPD) of laboratory duplicates will be less than or equal to 25 percent for values that are greater than 5 times the detection limit, and ±2 times the detection limit for values that are less than or equal to 5 times the detection limit.

- **Accuracy.** Accuracy will be assessed using laboratory preparation blanks, matrix spikes, and control standards. Where applicable, these quality control analyses will be performed for every sample batch at a frequency of at least 5 percent of the total number of samples submitted. The values for blanks will not exceed 2 times the detection limit. For inorganic analysis, the percent recovery of matrix spikes will be between 75 and 125 percent. The percent recovery of control standards for all samples will be between 80 and 120 percent. Large volume sample field blanks will also be submitted to determine recovery of the centrifugation step and background for the selenium analyses. The recovery must be within 30 percent.

- **Representativeness.** Sample representativeness will be ensured by employing consistent and standard sampling procedures.

- **Completeness.** A minimum of 95 percent of the sample analysis results reported by the laboratory will be judged valid. It is anticipated that all samples will be collected. An equipment checklist will be used to prevent loss of data resulting from missing containers or inoperable instruments prior to embarking on field sampling trips.

- **Comparability.** Data comparability will be ensured through the application of standard sampling procedures, analytical methods, units of measurement, and detection limits. The results will be tabulated in standard spreadsheets for comparison with threshold limits and background data.

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Data Assessment Procedures and Corrective Actions

Field and laboratory data will be reviewed by the quality assurance officer immediately upon receipt. Quality control problems and corrective actions will be summarized in a quality assurance worksheet. Values associated with minor quality control problems will be considered estimates and assigned a "J" qualifier. Values associated with major quality control problems will be rejected and assigned an "R" qualifier. Estimated values may be used for evaluation purposes, while rejected values will not be used. Data assessment procedures are described below for the following quality control elements:

- Completeness
- Methodology
- Holding times
- Blanks
- Detection limits
- Laboratory duplicates
- Matrix spikes
- Control standards.

Completeness

Completeness will be assessed by comparing valid sample data with this quality assurance project plan and the chain-of-custody records. Completeness will be calculated by dividing the number of valid values by the total number of values. Samples will be reanalyzed or re-collected if completeness is less than 95 percent.

Methodology

Methodology will be assessed by examination of the field notebook and laboratory reports for deviation from this quality assurance project plan. Unacceptable deviations will result in rejected values (R) and will be corrected for future analyses.

Holding Times

Analysis dates will be reported by the laboratory. Holding times will be assessed by comparing analytical dates to sample collection dates and times. Values that exceed the maximum holding time required by U.S. EPA (1992 and 1996) will be considered estimates (J), whereas severe exceedances will result in rejected values (R).

Blanks

Preparation blanks consisting of de-ionized distilled water will be analyzed and the results will be reported in each laboratory report. Sample values that are less than 5 times a detected blank value will be considered estimates (J).

Detection Limits

Detection limits will be reported in each laboratory report. If proposed detection limits are not met by the laboratory, the laboratory will be requested to reanalyze the samples and/or revise the method, if time permits.

Laboratory Duplicates

Precision of laboratory duplicate results will be presented in each laboratory report. Data for batch samples (i.e., samples from other projects analyzed with samples from this project) will be acceptable as long as project sample duplicates are analyzed at a frequency of at least 5 percent. Precision of field and laboratory duplicate results will be calculated according to the following equation:

> [EMBED Equation.3]
> where:
> RPD = relative percent difference
> C_1 = larger of two values
> C_2 = smaller of two values.

Laboratory duplicate results exceeding the objectives will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (J). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (R). Field duplicate results exceeding the objectives will be noted and only used to flag data upon consideration of all quality control data.

Matrix Spikes

Accuracy of matrix spike results will be presented in each laboratory report. Data for batch samples will be acceptable as long as spikes of project samples are analyzed at a frequency of at least 5 percent. Accuracy of matrix spike results will be calculated according to the following equation:

> [EMBED Equation.3]
> where:
> $\%R$ = percent recovery
> S = measured concentration in spike sample
> U = measured concentration in unspiked sample

C_{sa} = actual concentration of spike added.

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Results exceeding the objective will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (J). However, if the percent recovery exceeds 125 and a value is less than the detection limit, the result will not be flagged as an estimate. Nondetected values will be rejected (R) if percent recovery is less than 30 percent.

Control Standards

Accuracy of control standards will be presented in each laboratory report and checked by the quality assurance officer. Accuracy for these elements will be calculated according to the following equation:

[EMBED Equation.3]
where:
%R = percent recovery
M = measured value
T = true value.

Results exceeding the objective will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (J). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (R).

Data Management and Reporting

Water quality data will be entered in a numerical format in a Microsoft Excel spreadsheet following a quality assurance review. The results will be arranged chronologically for each station by sampling date across the spreadsheet columns. Data flags will be entered in separate columns adjacent to each data column using the following coding system:

- U = Analyte not detected at specified detection limit
- J = Estimated value
- R = Rejected value.

A monitoring report will be prepared upon completion of the data review and entry. This report will provide background information, data collection and analysis methods, tabulated and graphical presentations of the data, statistical test results, discussion of the results, conclusions, references, and appendices. Laboratory reports and quality assurance worksheets will be included in the monitoring report. Any problems and associated corrective actions taken will be reported. Specific quality assurance information that will be noted in the report includes the following:

- Changes in the monitoring/quality assurance plan

- Results of performance and/or system audits

- Significant quality assurance problems and recommended solutions

- Data quality assessment in terms of precision, accuracy, representativeness, completeness, comparability, and detection limits

- Discussion of whether the quality assurance objectives were met, and the resulting impact on decision-making

- Limitations on use of the measurement data.

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